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A monthly survey by the U. S. National Committee for the International Geophysical Year. Established by and part of the National Academy of Sciences, the Committee is responsible for the U. S. International Geophysical Year program in which several hundred American scientists are participating and many public and private institutions are cooperating.

Preliminary Reports: Satellites 1958 Alpha and 1958 Gamma

Preliminary reports on data gathered by US-IGY satellites 1958 Alpha and 1958 Gamma were made to members of the National Academy of Sciences, the American Physical Society, and the Washington scientific community at a special meeting held May 1, 1958, at the National Academy of Sciences in Washington, D. C. The reports discussed high intensity radiation, micrometeorites, satellite temperatures, and atmospheric densities.

Observation of High Intensity Radiation

J. A. Van Allen of the State University of Iowa, on behalf of himself and his colleagues G. H. Ludwig, E. C. Ray and C. E. McIlwain, gave a preliminary report on radiation intensities measured with single Geiger tubes carried by satellites 1958 Alpha and 1958 Gamma.[1]

The counting rate of the Geiger tube in 1958 Alpha was transmitted continuously. Data were recorded only when the satellite was near one of the 16 receiving stations distributed over the earth (Table 1).

[1] J. A. Van Allen, G. H. Ludwig, E. C. Ray, and C. E. McIlwain, "Observation of High Intensity Radiation by Satellites 1958 Alpha and Gamma," *IGY Satellite Report Series, No. 3: Some Preliminary Reports of Experiments in Satellites 1958 Alpha and 1958 Gamma*, (National Academy of Sciences, Washington) pp. 73–92.

The data collected by 1958 Gamma were also telemetered continuously. In addition, a small magnetic tape recorder stored the data obtained during each entire orbit. Then, as the satellite passed near one of the receiving stations, a radio command from the ground caused these data to be read out.

A preliminary study of part of the data obtained from 1958 Alpha and from several interrogations of 1958 Gamma has been carried out, with the following results.

Reasonable cosmic ray counting rates have been obtained for altitudes below about 1000 km. In particular, a plot of intensity against height in the vicinity of California for the first two weeks in February, has been constructed. This curve, extrapolated down to altitudes previously reached by rockets, agrees with earlier data (Fig. 1).

At altitudes greater than about 1000 km, a very high intensity of radiation was encountered. This radiation was of such an intensity as to exceed the design capabilities of the electronic system for either direct transmission or for stored and played-back transmission. But the approximate magnitude of the intensity was determined by detailed study of the data and by laboratory calibration of the overall electronic system. It is estimated that for portions of the orbits of 1958 Alpha and 1958 Gamma, a Geiger tube of zero dead time would have been

Table 1. *Receiving Stations*

Minitrack

Blossom Point, Maryland
Fort Stewart, Georgia
Antigua, British West Indies
Havana, Cuba
San Diego, California
Quito, Ecuador
Lima, Peru
Antofagasta, Chile
Santiago, Chile
Woomera, Australia

Microlock

Patrick Air Force Base, Florida
Earthquake Valley, California
Singapore
Ibadan, Nigeria
Temple City, California
Pasadena, California

Note: The Minitrack and Microlock radio tracking programs are under the direction of the Naval Research Laboratory and the Jet Propulsion Laboratory of the California Institute of Technology, respectively.

producing over 35,000 counts/sec, or on the order of 1000 times the cosmic ray rate.

It is surmised that the newly discovered radiation is closely related to that previously found by the Iowa group above 50 km with rocket flights in the auroral zones.

Several important geophysical effects of this radiation are suggested. It is very likely closely related to auroras and geomagnetic storms. In addition, a rough calculation suggests that the radiation may be sufficiently intense to contribute important heating to the upper atmosphere. Also, the consequences in the production of atmospheric ionization, light, and radio noise are being investigated.

The directly observed effects in the satellite equipment are believed due to X-rays (bremsstrahlung) produced by the impact on the equipment of electrons of the interplanetary plasma which comes from the sun and encounters the environment of the earth.

Figure 2 exhibits a typical record of apparent counting rate against time obtained in an interrogation from San Diego at 1748 UT on the 28th of March. During the first 13 min (near perigee) the rate was well within the design capabilities of the system.

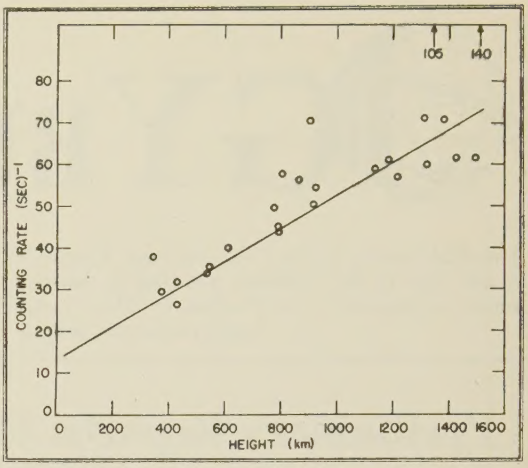

Fig. 1. *Graph of Variation of Cosmic Ray Intensity with Height in the Vicinity of California During the First Two Weeks of February 1958.*

Between 13 and 15 min the rate rose rapidly to exceed 128 counts/sec and remained above that value until 20 min had passed. Between 20 and 37 min the *apparent* counting rate was zero. This performance is interpreted as due to an equivalent rate exceeding 35,000 counts/sec (or 60 milliroentgens/hr of 80 kev X-rays)—i.e., a sufficient intensity of radiation to reduce the height of all Geiger tube pulses below the threshold level for triggering the scaling circuit. From 38 to 87 min the equivalent rate lay between 35,000 and 128 counts/sec, and again, near perigee of the orbit, from 87 to 107 min, the counting rate had the low value attributable to cosmic rays only.

A summary of counting rate data of this sort for several orbits of 1958 Gamma is given in Figure 3. Note that during the period March 28–31 the perigee was approximately at the most northerly latitude; hence, the altitude was low at high northerly latitudes and high at high southerly latitudes. Data from the continuous channels of 1958 Alpha and 1958 Gamma are concordant with each other and with data shown in Figure 3.

Preliminary interpretation of the data has been guided by the extensive knowledge which has been obtained by many rocket and balloon studies of the "soft radiation" in the

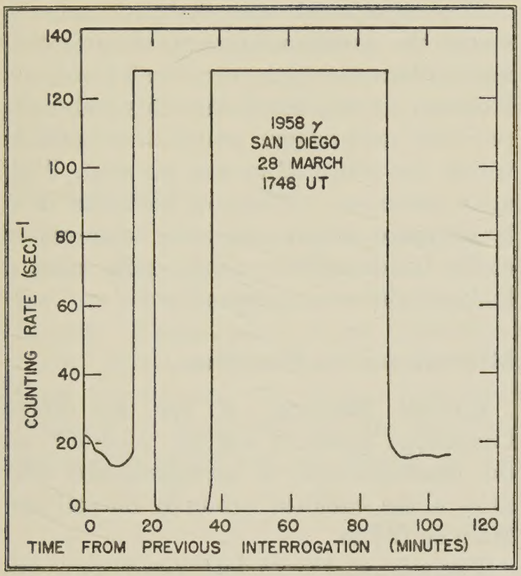

Fig. 2. *Record of Interrogation of 1958 Gamma.*

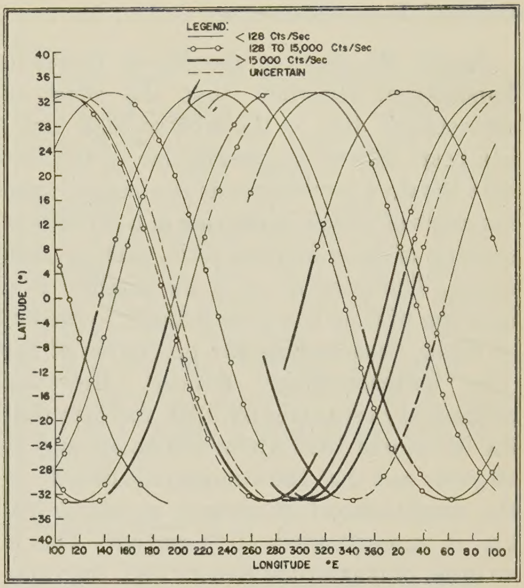

Fig. 3. *Counting Rate Data for 1958 Gamma Through Several Orbits, March 28–31, 1958.*

auroral zones. (See *IGY Bulletins* Nos. 3, 5, and 10.)

The satellite observations on which the present report is based are only a small portion of those available and now under systematic study.

Optical Studies

G. F. Schilling reported[2] on results from optical tracking of US satellites, based on work done by Charles A. Whitney, Theodore E. Sterne, and Luigi G. Jacchia at the Smithsonian Astrophysical Observatory. Preliminary analysis of the data obtained by visual observations and precise photographic observations has supplied information on the spin of 1958 Alpha, on air density at very high altitudes, and on the expected lifetime of 1958 Alpha.

Charles A. Whitney found[3] that 1958 Alpha, which was given a spin about its long axis during launching, now appears to rotate about its short axis, propeller-like. This conclusion is based on an observed variation of orbital acceleration.

Theodore E. Sterne has developed[4] a simplified formula for computing the air density at very high altitudes from the motion of artificial satellites. This formula, applied to orbital data inferred by Whitney through a critical study of visual and radio observations of 1958 Alpha, gives an air density value of about 1.5×10^{-14} gm/cm^3 at an altitude of 368 km. A cubic mile of air of this density would weigh only two ounces. Nevertheless, the density is about 15 times greater than that predicted in 1956 by R. A. Minzner and W. S. Ripley of the Air Force Cambridge Research Center.

Luigi G. Jacchia, using a formula developed by D. C. M. Leslie, and density values from the Smithsonian Interim Atmosphere of Sterne, Folkart, and Schilling, estimates[5] that 1958 Alpha will fall toward the end of 1962.

[2] "Status Reports on Optical Observations of Satellites 1958 Alpha and 1958 Beta," ed. by G. F. Schilling, *op. cit.*, pp. 1–15.

[3] C. A. Whitney, "The Orbit and Variable Acceleration of Satellite 1958 Alpha," *op. cit.*, pp. 6–9.

[4] T. E. Sterne, "The Density of the Upper Atmosphere," *op. cit.*, pp. 10–14.

[5] L. G. Jacchia, "Life Expectancy of Satellite 1958 Alpha," *op. cit.*, p. 15.

Orbital Determinations

Joseph W. Siry, of the Naval Research Laboratory, reported[6] that the effect of atmospheric drag on the orbit of 1958 Alpha has been difficult to predict due to the fact that the drag force depends so strongly upon the angle of attack in the case of a cylindrical satellite of large fineness ratio, such as 1958 Alpha. The orientation of the satellite as a function of time has been difficult to predict at times, thus making the prediction of the orbit correspondingly difficult. However, preliminary estimates by NRL indicate that the lifetime of 1958 Alpha will be about 5 to 10 years and that the atmospheric density in the neighborhood of perigee, at about 370 km, is approximately 10^{-14} gm/cm^3. This is an order of magnitude greater than the value predicted for this altitude in 1956 by Minzner and Ripley.

Temperature Measurements

A. R. Hibbs and E. P. Buwalda, of the California Institute of Technology Jet Propulsion Laboratory, reported[7] on a passive solution of space temperature problems and on temperature measurements made by 1958 Alpha. Internal temperatures ranged from 0°C to 35°C inside the cylinder and from 5°C to 40°C inside the nose cone. Shell temperatures ranging from −25°C to 75°C were recorded.

The temperature control mechanism consists of a series of aluminum oxide stripes covering approximately 25% of the outer surface of the cylindrical section of the instrument compartment, and 30% of the outer surface of the nose cone. By both reflecting and re-radiating heat received from the sun and the earth, this coating maintained interior temperatures within the range needed to protect instrumentation from damage by heat or cold.

[6] J. W. Siry, "The Determination of the Orbit of 1958 Alpha at the Vanguard Computing Center," *op. cit.*, pp. 16–23.

[7] A. R. Hibbs and E. P. Buwalda, "Satellite Temperature Measurements for 1958 Alpha-Explorer I," *op. cit.*, pp. 31–72.

The experiment was designed only to study the problem of controlling instrument environment in a very small enclosure. However, it was noted that this technique provided temperature control in a satellite within the range of human survival. With more elaborate techniques, available in a larger space vehicle, the inner temperature could be controlled within quite narrow limits at almost any desired level.

Micrometeorite Densities

Edward Manring, of the Air Force Cambridge Research Center, reported[8] on the determination of micrometeorite densities in the satellites' orbits by himself and Maurice Dubin.

Two micrometeorite detection systems are used. One, called the gauge detector, is carried on both 1958 Alpha and 1958 Gamma. The individual gauges are one cm^2 in area and are wound with two layers of enameled wire 17 microns in diameter. Twelve of these gauges, covering an area of two square inches, are mounted in a circular pattern flush with the surface of the satellite's mid-section. When a micrometeorite of 5- to 10-microns diameter and travelling at meteor velocities, on the order of 25,000 mph, smashes into one of the gauges, the continuous circuit breaks and changes the transmitted signal.

The second detector, flown only on 1958 Alpha, consists of a crystal microphone mounted against the skin of the satellite and connected to an amplifier. When the satellite is struck by a solid particle, the impact pressure is converted into an electrical signal which is transmitted to the monitor stations.

About 10% of the microphone data and 50% of the gauge data from 1958 Alpha are available for study. Seven hits have been detected by the microphone, but after 32 days of flight only one gauge had registered an impact. The data indicates that the average influx of particles 10 microns in

[8] E. Manring and M. Dubin, "Satellite Micrometeorite Measurements," *op. cit.*, pp. 25–29.

diameter or greater was not more than $10^{-3}/m^2/sec$ during the period of observation, and that the average influx of particles four or more microns in diameter was about $10^{-2}/m^2/sec$.

Recapitulation

The above reports reflect preliminary results obtained from 1958 Alpha and, in the case of cosmic rays, from 1958 Gamma. Reports incorporating these preliminary results have now been sent to IGY World Data Centers and the Special Committee for the IGY. Analysis of the data from these satellites is continuing and will be the subject of further papers at an appropriate time.

There have been six satellites launched during the International Geophysical Year, three by the U. S. and three by the U.S.S.R.

The first USSR satellite, 1957 Alpha, is described in *Bulletin No. 5*; the second, 1958 Beta, is described in *Bulletin No. 6*. A report on 1958 Delta, the third USSR satellite, appears in the present issue of the *Bulletin*.

During the remainder of the US-IGY satellite program, satellite launchings will take place at the rate of about one a month, carrying a variety of experiments selected by USNC-IGY.

Third Soviet Satellite

The USSR launched its third artificial earth satellite, 1958 Delta, in the early morning of May 15, 1958. Following are selections from descriptive text issued on that date by Tass:

"In conformity with the program of the IGY a third artificial earth satellite was launched in the Soviet Union on May 15, 1958. The launching of the artificial satellite is intended for scientific research in the the upper layers of the atmosphere and cosmic space.

"The satellite entered its orbit inclined by 65 degrees to the plane of the equator. According to initial data, the greatest distance of the orbit from the surface of the earth is 1,880 kilometers [1168 mi]. The time of each revolution around the earth is 106 minutes. The satellite is separated from its carrier rocket which is following along a close orbit. . . .

"The third Soviet artificial earth satellite is conical in shape. The diameter of the base is 1.73 meters [5′8″] while its height is 3.57 meters [11′9″] not counting protruding aerials. The weight of the satellite is 1,327 kilograms [2925.5 lbs] including the weight of instruments for scientific research, radio measuring apparatus, and batteries weighing 968 kilograms [2134 lbs]."

Radio Moscow reported on May 15 that 1958 Delta ". . . carries equipment making it possible to carry out research along the entire orbit . . . [on] pressure and composition of the atmosphere in the upper layers; concentration of positive ions; the magnitude of the electrical charge of the satellite and the tension of the earth electrostatic field; tension of the magnetic field of the earth; intensity of the sun's corpuscular radiation; composition and variations of the primary cosmic radiation; distribution of photons and heavy nuclei in the cosmic rays; micrometeors; temperature inside and on the outside of the satellite."

Radio Moscow reported further that ". . . the satellite carries a multi-channel telemetric system with a high selectivity . . . [and] special transmitting installations which enable the carrying out of the measurements of the coordinates of its trajectory.

". . . it carries a transmitter continuously transmitting signals on 20.005 megacycles with a duration of 150–300 milliseconds and with a high power of transmission.

"The scientific and radio technical equip-

ment installed in the satellite is controlled by a programming device. In addition to electrochemical sources of power, the satellite carries solar batteries. . . ."

On May 18, Pravda stated that the airtight satellite is made of aluminum alloys and is filled with gaseous nitrogen.

Radio signals from the satellite were first picked up abroad by the observatory of the University of Bonn, in Bonn, West Germany, at 6:15 am EDT, May 15, 1958. In this country the signals were first received by RCA Communications, Inc., at Riverhead, L.I., at 10:06 am EDT, May 15. First reception by a facility in the Naval Research Laboratory's Minitrack Network was at Woomera, Australia, at 8:35 am EDT, and, in this country, at the Ft. Stewart, Georgia, and Blossom Point, Maryland, Minitrack stations, both at 11:52 am EDT, May 15.

The first visual sighting of the satellite by a Moonwatch team in this country was reported by Robert C. Lehman, leader of the team at Harrisonburg, Virginia. Harvey Mast and Linford Gehman, members of this team, observed the satellite simultaneously at 9:03 pm EDT, May 15, 1958. The satellite was seen on its ninth revolution around the earth as an object of variable brightness, but of the first magnitude when at its brightest.

The first photograph of the satellite at a precision optical tracking station of the Smithsonian Astrophysical Observatory was taken by a Super Schmidt camera on Maui, Territory of Hawaii, at 0627 UT (2:27 am EDT), May 16, 1958.

Preliminary Report on the Thickness of Ice in Antarctica

The following report is based on material supplied by George P. Woollard, Department of Geology, University of Wisconsin.

Prior to the IGY, the only knowledge of the thickness of the Antarctic ice cap was obtained on the Norwegian-British-Swedish Expedition of 1949–52 to Queen Maud Land and on the earlier US expeditions led by Admiral Byrd. While the Byrd expedition measurements were all made in the vicinity of the Ross Ice Shelf, the Norwegian-British-Swedish expedition conducted a traverse from the sea ice onto the ice plateau, covering a distance of over 380 mi.

The feasibility of scientific over-snow traverse operations in the Antarctic was thus demonstrated; the results obtained constitute a milestone in the scientific exploration of Antarctica that ranks along with those of the Scott, Shackleton, Mawson, and Byrd expeditions. As a consequence, the US-IGY scientific program in Antarctica, along with that of other nations, includes seismic over-snow traverse operations as an integral component.

Information on ice thickness in Antarctica serves a number of scientific purposes. It sheds direct light on the glacial history of the Antarctic continent; in a broader sense it may reveal much of relevance to past and present world climatology. In a very different area, measurement of the flexure of the earth's crust under its enormous load of ice should yield data on crustal strength.

There are, in addition, practical as well as scientific considerations in studying the thickness of the Antarctic ice cap, as well as the Greenland, Ellesmere Island, Baffin Island, and other ice caps. If substantial portions of the Antarctic ice cap should melt, the volume of water released would profoundly influence sea level; some coastal cities might be completely submerged or

develop into counterparts of Venice, with canals marking former streets. In fact, surveys indicate that certain former ice cap centers, such as Canada and Scandinavia, are rapidly rising, and many seaport towns that flourished when Rome was a world power are now marked only by their submerged ruins. (Carbon-14 dating shows that it has been only about 10,000 years since the retreat of the Wisconsin ice sheet—the last great advance of ice during the "Ice Age"—from the United States into Canada.)

Techniques of Measurement

To investigate the Antarctic ice cap, a multiple attack has been mounted utilizing the techniques of glaciology, seismology, gravity, magnetism, and geology, including photo-geology and submarine geology. In exposed-rock areas along the coasts it is possible to carry out geologic studies of the morainal material left at former positions of the ice front and to deduce the number of past advances and retreats of the ice. Similar information can be obtained from submarine cores taken from the adjacent sea floor.

From visual observation, and in particular from the study of air photos, considerable information can be obtained as to the former height of ice in valleys that may now be either ice-free or only partially ice-filled. The study of variations of ice density with depth, as observed from cores, in pits, and and from isotope dating of the ice at different depths, gives information concerning variations in the rate of ice accumulation in the recent past. While the actual thickness of ice can be obtained by drilling, this technique is both costly and slow. Only one deep boring, to study the nature of the ice rather than its depth, was included in the Antarctic program.

Seismic: The primary technique used for determining the ice thickness is that of seismology; it is based on the time it takes a sound wave to penetrate the ice and be reflected back to the ice surface from the underlying rock or water surface. This method, so long as the wave velocity in the ice is relatively constant, is as reliable for determining depth as direct drilling. Moreover, it costs only a fraction of the drilling cost, and a seismic measurement can be carried out in only a few hours compared to days, weeks, or months using a drill.

Although the time needed for a seismic measurement is small compared to drilling, it is lengthy compared to the time required for gravity or magnetic measurements, which can also be used for estimating ice thickness. These measurements can be completed in less than ten minutes. However, in contrast to seismic measurements, gravity and magnetic measurements are not significant by themselves. It is necessary first to compute a theoretical value of what the measurement should be in terms of the location and elevation of the particular observation site. The difference between this theoretical value and the observed value is used in estimating the ice thickness. Such differences are referred to as gravity and magnetic *anomalies*. As these anomalies are caused by horizontal variations in the factors measured, they form areal patterns of "highs" and "lows", which look very much like topographic contour maps.

Gravity: For effective use of gravity data, the latitude and elevation of the observation site must be known, as well as something about the density of the underlying crustal material. The force of gravity increases poleward owing to the shortening of the earth's radius as the poles are approached and to the reduced centrifugal force caused by the earth's rotation. In addition, there is a theoretical decrease of gravity with elevation, although it tends to be offset by the corresponding increase in mass of the material above sea level. In general, gravity values are related directly to the subsurface mass distribution, highs indicating excess mass and lows deficiency in mass.

Magnetic: In deriving magnetic anomalies, changes in the strength and inclination of the earth's magnetic field with both lati-

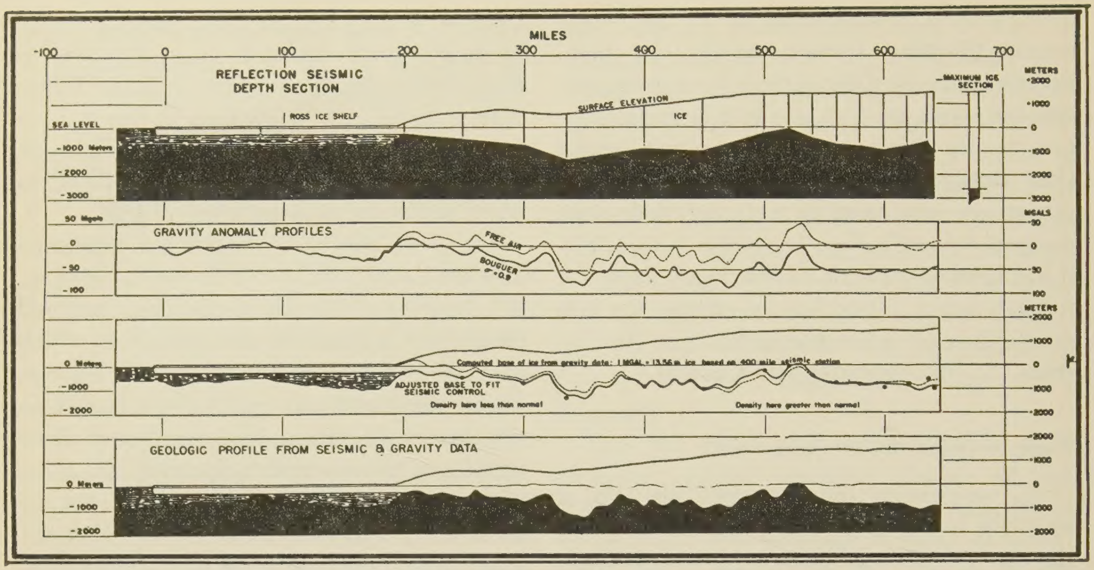

Fig. 4. *Seismic, Gravity, and Resulting Geologic Profile for Traverse Route from IGY Little America Station to IGY Byrd Station.*

tude and longitude must be considered as well as diurnal and secular, or long period, changes. To obtain magnetic anomaly values, corrections for these variations are applied directly to observed values. However, the derivation of magnetic anomalies is complicated by the fact that the pattern of highs and lows is influenced by the proximity of minor poles of magnetism induced on the boundaries of the disturbing rock mass by its geometry and its orientation in the earth's field.

Combined Techniques: By constructing profiles based on the anomaly patterns obtained by both gravity and magnetic techniques, it is possible to use the gradients on the flanks of individual highs and lows to calculate a minimum depth of origin of the anomalies. In the case of crystalline rocks underlying an ice sheet, this depth can be regarded as equivalent to the depth of the ice. Estimates of ice depth using gravity or magnetic techniques alone are far from exact, however, and errors of 20% or more are possible.

High magnetic anomalies are usually associated with gravity highs related to variations in the underlying crystalline rock, but magnetic effects resulting from variations in underlying rock configurations are small. Hence, it is possible to choose points for which the relationship between gravity-anomaly values and seismic depth measurements is significant. In this way, the gravity program can become an important adjunct to the seismic program for determining the the thickness of an ice sheet.

The method actually employed for determining the depth sections shown in the lower part of Figure 4 was to equate the seismically-determined depth below sea level at the 400-mile station to a type of gravity anomaly (Bouguer) value. This established the relation 1 mgal = 13.56m (or 44.32 ft) of ice. The Bouguer anomaly values were thus first interpreted as shown by the dashed line and then empirically adjusted on a sliding scale to account for apparent horizontal variations in ice density, possible inclusion of morainal material, or regional variations in the kind of underlying rock. This gave the best overall fit to all of the seismic depth data. The final depth profile arrived at in this way is shown at the bottom of Figure 4. Although none of the depth

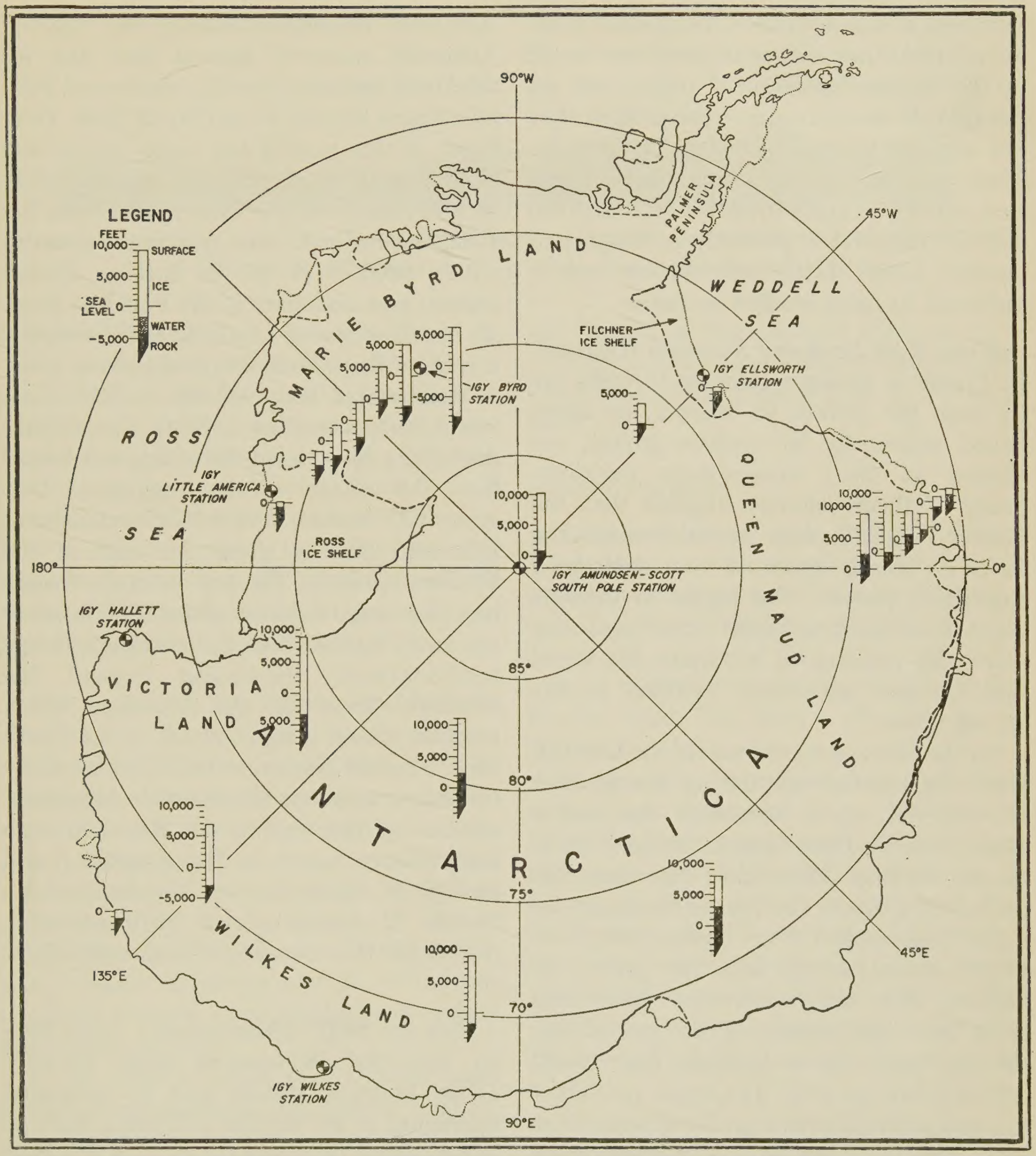

Fig. 5. *Geologic Columnar Sections Showing Ice Thickness of Portions of Antarctica.*

values shown in the top profile, based on seismic data alone, have been significantly changed, the overall character of the profile has been materially modified by the inclusion of the gravity measurements.

The procedure used on the IGY Antarctic oversnow traverses, was, therefore, to take seismic depth measurements at roughly 30- to 50-mile intervals and gravity and magnetic observations, which require only a few minutes, at intervals of two to five miles. This combined program of seismic, gravity, and magnetic measurements supplies geological and geodetic data as well as glaciological data.

Results

While it is too early to give comprehensive results for the program to determine ice

thickness in the Antarctic, a sufficient number of seismic measurements have been made by the various international teams and on the 1957–58 oversnow traverses to show that the average thickness is 8000 ft or more. They also indicate that the underlying bedrock surface is quite irregular and that the bedrock material is probably a complex of igneous rocks. Little sedimentary rock is indicated in areas studied to date.

Marie Byrd Land and Ellsworth Highland: In Figure 5, geologic columns through the ice from the surface to bedrock, as determined seismically by various groups, are plotted at their approximate positions. Study of these columns suggests that the Palmer Peninsula may extend beneath the ice as an island, separated by a strait from Antarctica proper. The region of extreme depth to bedrock in Marie Byrd Land may mark the position of a former sea strait that became completely ice-filled as the ice cap grew.

On the first and second legs of the US-IGY Byrd Station traverse during the summer of 1957–58, which extended the earlier Little America-Byrd Station profile (Fig. 4) to the Sentinel Mountains, less than 350 mi from the base of the Palmer Peninsula, ice thicknesses ranged from about 2000 ft to 11,500 ft and, except for a few peaks, the bedrock floor was everywhere below sea level. Near the middle of the second leg, the ice rested on a bedrock floor about 6500 ft below sea level. The major portion of the area included in this profile appears to be far enough below sea level to be under water even if the ice cover were removed and isostatic balance reestablished by uplift of the ice-freed surface. On the third leg, the bedrock floor was found to be rough and mostly above sea level, with nunataks (isolated peaks breaking through the ice) appearing in several places. Near the end of the third leg, an ice thickness of over 14,000 ft—the greatest ever recorded—was measured.

Weddell Sea to South Pole: Seismic soundings taken on the Commonwealth Trans-Antarctic Expedition during the 1957–58 Antarctic summer, showed that the ice thickness increases steadily southward from Shackleton Station to the South Pole. Over much of this part of the route the ice was about 6000 ft thick. At approximately 88°30′S, however, less than 100 mi from the Pole, the bedrock base appeared to rise to within 2000 ft of the ice surface. Earlier seismic measurements at the Pole had given an ice thickness of about 8300 ft overlying a rock surface about 900 ft above sea level.

Members of the 1957–58 US-IGY Ellsworth Station traverse in Edith Ronne Land detected a deep trough extending southward from the vicinity of the Argentinian Belgrano IGY Station, about 35 mi southeast of Ellsworth Station along the edge of the Filchner Ice Shelf. The bottom of the trough has an average depth of about 3500 ft below sea level. Farther inland, the trough swings southwestward, continuing beyond the southerly limit of the traverse, which reached within about 550 mi of the South Pole. Further seismic traverse work will be needed to ascertain whether this depression extends all the way to the Ross Sea. (An early theory based on the geography and geology of Antarctica and the nearby continents of Australia and South America postulated the existence of such a trough.)

Ross Ice Shelf: Measurements made both on the 1957–58 traverse from US-IGY Little America Station and by personnel remaining at the station indicate a more or less constant thickness for most of the shelf of about 1000 ft. Near the edge, however, thicknesses range from about 790 to 1050 ft, and at the Beardmore Glacier, along the poleward margin of the shelf, the ice is 1380 ft thick. The surface of the shelf is 165 ft higher at the Liv Glacier than at the Beardmore. Since the shelf is believed to be afloat in the Liv Glacier region, this constitutes a considerable increase in ice thickness. The only evidence of grounding of the shelf was on and around Roosevelt Island and at 83°30′S, 163°–169°W.

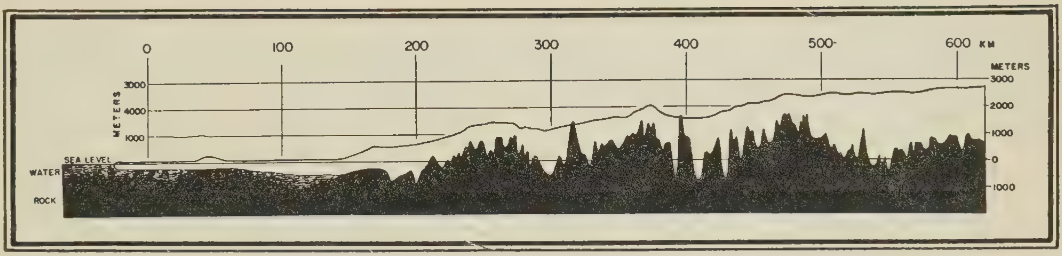

Fig. 6. *Seismic Profile Along Route of Norwegian-British-Swedish Traverse.*

Queen Maud Land: As shown in Figure 6, which is a seismic profile along the route of the Norwegian-British-Swedish expedition in 1948-52, the sub-ice surface is below sea level for at least 125 mi inland, and for a distance up to about 280 mi, there are still some areas with bedrock surfaces below sea level. The maximum ice thickness approaches 10,000 ft in the last 50 mi of the traverse. The configuration of the rock surface beneath the ice is quite irregular.

East Antarctica: During the past Antarctic summer, a party from the Australian Mawson IGY Station, at 67°36′S, 62°53′E, conducted a continuous seismic traverse for more than 400 mi south from the station. About 200 mi inland, over a point where the sub-ice surface rose to a height of 3000 ft above sea level, the ice was about 5000 ft thick. Normal ice thicknesses in this region and to the south were greater. In most places along the traverse route, the bedrock surface was above sea level.

At the USSR Vostok IGY Station, near the south geomagnetic pole almost 1000 mi into the interior of the continent, an ice thickness of 8700 ft was reported. The bedrock surface beneath the station is 2300 ft above sea level.

At station C (77°22′S, 139°48′E) of the US-IGY airborne traverse conducted in Victoria Land during the 1957–58 summer season, a possible ice thickness of 12,500 ft was measured. Distinct ice-bottom reflections were not obtained, however; it is surmised that the bottom topography in this region is too rough to serve as an efficient seismic reflector. Figure 5 shows an ice thickness of more than 9000 ft at the French Charcot Station, a few hundred miles north of station C. The bedrock surface beneath the Charcot Station is nearly 3000 ft below sea level.

Crustal Flexure

Analysis of the anomaly profiles in Figure 4 suggests crustal warping inland, with sufficient displacement of denser subcrustal material to establish isostatic equilibrium for the superimposed load of ice. It also indicates that there is no appreciable crustal flexure within the border area of the ice plateau.

The fact that the rock surface at the base of the ice is either close to sea level or well below it throughout much of Antarctica suggests considerable flexure of the continental crustal material. It is hoped that during the post-IGY period it will be possible to obtain extended gravity and seismic measurements in the offshore area so that the degree of crustal displacement caused by the ice load on shore can be directly evaluated.

Reduction of New Data

At the Antarctic Gravity and Seismological Data Reduction Center at the University of Wisconsin, profiles are now being prepared for the various traverses carried out during the 1957–58 summer season in the US-IGY Antarctic Program. The center is manned by personnel who took part in these traverse operations. Now working there are E. C. Thiel and J. C. Behrendt, from IGY Ellsworth Station, E. S. Robinson and H. F. Bennett, from IGY Little America Station, and N. A. Ostenso, from IGY Byrd Station.

From similar studies carried out by various teams of investigators in different parts of Antarctica next summer and in the post-IGY years, scientists will soon have a better picture of this once remote continent, its ice cap, its geologic makeup, and its potential for influencing sea level and world geography in the future.

Rocket Results at Fort Churchill

By July 1, 1958, a total of 116 rockets had been fired in the US-IGY Rocket Program. This number includes rockets fired in programs conducted at Fort Churchill (21 Aerobees, 20 Nike-Cajuns); White Sands (two Nike-Cajuns, one Aerobee, one Nike-Asp); Alamogordo, New Mexico (two Aerobees); Point Mugu, San Nicolas Island, California (14 Nike-Deacons, one Nike-Asp); a shipborne operation in the Arctic (18 Rockoons); and a shipborne operation in Pacific and Antarctic waters which was concluded in mid-November 1957 (36 Rockoons). (See *IGY Bulletins 7*, *5*, and *11* for accounts of the latter 3 operations.)

The major effort of the US-IGY rocket program is centered at the rocket launching facilities especially constructed for the IGY in cooperation with the Canadian Government and the Canadian IGY Committee at Fort Churchill, Manitoba, Canada. Thirty-three of the 41 launchings here have resulted in good rocket performance and satisfactory data. In addition, 6 of 7 rockets fired from the same facility prior to the IGY produced satisfactory experimental data. During a single 48-hour period in January 1958, in the midst of the Arctic winter, 5 rockets were successfully launched.

Experimental Results

Table 2 lists the rockets fired from Fort Churchill, the instrumentation carried, the performance of the rocket, and the success of the experiment. The major scientific results for each experiment are summarized below.

Participating research organizations include the Air Force Cambridge Research Center, University of Michigan, Naval Research Laboratory, Signal Engineering Laboratories, State University of Iowa, and the Army Ballistic Research Laboratories.

Ion Composition of the Arctic Ionosphere: Three Aerobee-Hi rockets instrumented with radio-frequency mass spectrometers were launched to peak altitudes of from 200–250 km. Positive and negative ions were detected on all three flights. It was found that ionized nitrogen oxide was a very important constituent of the ionosphere below 200 km and that during the daytime ionized molecular oxygen is present below 100 km and ionized atomic oxygen is present above 150 km. This new information on the electrical composition of the lower ionosphere is of great importance to theoretical studies of the interaction of solar radiation and atmospheric molecular constituents.

Structure of the Arctic Upper Atmosphere: Results from two Aerobee-Hi rockets launched during 1956–57 have been compared with structural information derived from rockets launched during 1953–54 from high altitude skyhook balloons. Tentative results indicate that at 200 km the summer daytime atmosphere density at 59°N is 2.5 times the winter daytime value; and 20 times the winter nighttime value. The summer daytime value is 6.5 times the corresponding value at White Sands, New Mexico.

At lower altitudes, between 30–45 km,

density measurements indicate that seasonal and latitude variations are less than 10%, while summer pressure measurements show Arctic temperatures and pressures at these altitudes to be significantly higher than values determined at lower latitudes.

Diffusive Separation of Gases in the Upper Atmosphere: Diffusive separation of gases under gravity in the ionosphere plays an important role in the modification of the composition of the upper atmosphere. An experiment carried out during the Arctic winter night measured the composition of the upper atmosphere between 105–240 km by means of a radio-frequency mass spectrometer. Ninety-six spectra were obtained on the ascent of the rocket and seven spectra on the descent of the rocket. Analysis of these spectra shows diffusive separation of argon and nitrogen in the region 112–150 km. Data obtained on the general composition of the upper atmosphere over the regions covered in flight also show the presence of atomic oxygen.

Meteorological Soundings: Some 30 upper atmosphere rocket soundings measured temperature, pressure, density and winds. Experiments have included the freely-falling sphere for measuring densities, the rocket-grenade experiment for the measurement of temperatures and winds, and several aerodynamic techniques for measuring pressures and densities in the supersonic flow.

Many of these rockets attained altitudes greater than 200 km, and thus the first density measurements made at high latitudes were recorded. Launchings were made during both summer and winter, day and night. The resulting data indicate that the density of the high atmosphere is under strong solar control. There appear to be a latitude effect, a seasonal effect, and a strong diurnal effect; none of these effects appear at lower altitudes at Fort Churchill or at lower latitudes.

A firing at Fort Churchill measured the first atmospheric temperature maximum at an altitude of about 60 km. Normally this maximum is found below 50 km at lower latitudes, indicating that, at northern latitudes, the temperature rise is more gradual. (Temperatures decrease up to the stratosphere, rise during the next 20 to 30 km, decrease through the next 30 km, and then rise again.)

The temperature data have shown that the winter measurement is characterized by low temperatures below 50 km. The summer results, by contrast, show extremely low temperatures at 30 km.

Winds measured at Fort Churchill have the characteristic summer-winter difference which has been observed in lower latitude measurements. The winds are weak and from the east in the summer, very strong and from the west in the winter.

Electron Density Measurements: Four Aerobee-Hi rockets have been launched to study the ionosphere above Fort Churchill. The resultant data show the ionosphere to be a single layer, strong during the day and weak at night. Two of the rockets made important discoveries. These launchings took place during "polar blackouts," periods of disrupted communications at high latitudes. The rockets have shown that the "blackout" is due to a very dense and low "D" region of the ionosphere. It has been determined that this dense region exists at a significantly lower altitude, and with a much greater density, than is found at lower latitudes. These data will be especially useful for effecting improved radio communications.

Horizon Studies—Water Vapor Structure: On March 24, 1958, the first of a planned series of five Nike-Cajun rockets was fired to obtain photographs of the horizon at a high latitude geographical location. These photographs, which show the haze surrounding the earth as a band at the horizon, reveal water vapor structure as bright lines in the haze horizon band.

Tentative results from this flight show a single tropopause structure at Fort Churchill with little evidence of fine structure. In addition, it is evident that the brightness profile

Table 2. *US-IGY Rocket Results at Fort Churchill to 1 June, 1958*

IGY Rocket No.	Launching Date	Experiment	Results		
			Experiment performance	Rocket performance	Peak altitude (Miles)
			Pre-IGY		
AM 6.31	20 Oct 56	PTD	Sat	Normal	70
AM 2.21	23 Oct 56	PTD	Sat	Normal	90
NN 3.02	5 Nov 56	AP	Unsat	Unsat	Unknown
SM 1.01	12 Nov 56	TW	Sat	Below Pred.	42
NN 3.07	15 Nov 56	AP	Sat	Below Pred.	80
NN 3.12	17 Nov 56	PD	Sat	Normal	130
NN 3.17	20 Nov 56	CIC	Sat	Normal	158
			During IGY		
NN 3.08F	4 Jul 57	CD	Sat	Normal	160
NN 3.09F	4 Jul 57	CD	Limited Data	Unsat	10
SM 1.02	22 Jul 57	TW	Sat	Normal	57
SM 1.03	23 Jul 57	TW	Sat	Normal	54
NN 3.13F	29 Jul 57	PTD	Sat	Normal	131
AM 6.32	30 Jul 57	PTD	Unsat	Unsat	14
SM 1.04	12 Aug 57	T	Sat	Below Pred.	46
SM 1.05	19 Aug 57	TW	Sat	Normal	58
RPX 6.X1	23 Aug 57	Test	Sat	Normal	70
SS 6.38	24 Aug 57	TW	Unsat	Unsat	Unknown
SM 2.06	25 Aug 57	TW	Sat	Normal	81
II 6.22F	27 Aug 57	AP, C	No Data	Unsat	Unknown
II 6.23F	30 Aug 57	AP, C	Limited Data	Normal	70
AM 4.01	1 Sep 57	PTD	Sat	Sat	99
SS 6.39	10 Dec 57	TW	Unsat	Unsat	Unknown
SM 1.07	11 Dec 57	TW	Sat	Normal	53
SM 1.08	14 Dec 57	TW	Sat	Normal	50
AM 6.34	14 Dec 57	PTD	Unsat	Unsat	Unknown
AM 6.02	25 Jan 58	PTD	Sat	Normal	100
NN 3.03F	25 Jan 58	AP, M	Sat	Normal	112
SM 1.09	27 Jan 58	TW	Sat	Normal	61
SM 2.10	27 Jan 58	TW	Sat	Normal	94
AM 6.36	27 Jan 58	PTD	Sat	Normal	80
AM 6.03	29 Jan 58	PTD	Sat	Normal	100
NN 3.10F	3 Feb 58	CD	Sat	Below Pred.	86
NN 3.11F	4 Feb 58	CD	Sat	Normal	146
II 6.24F	13 Feb 58	AP, C	Sat	Below Pred.	80
II 6.25F	16 Feb 58	AP, C	Sat	Below Pred.	75
NN 3.18F	21 Feb 58	CIC	Sat	Normal	140
II 6.26F	21 Feb 58	AP, C	Sat	Below Pred.	80
NN 3.14F	24 Feb 58	PTD	Sat	Below Pred.	128
AM 6.37	24 Feb 58	PTD	Sat	Normal	89
II 6.27F	24 Feb 58	AP, C	Sat	Below Pred.	80
RPX 6.X2	26 Feb 58	Test	Sat	Unsat	Unknown
AM 6.04	4 Mar 58	PTD	Failed	Unknown	Unknown
AM 6.05	4 Mar 58	PTD	Sat	Normal	105
NN 3.04F	15 Mar 58	AP	Sat	Below Pred.	78
NN 3.05F	22 Mar 58	AP	Sat	Normal	104
NN 3.19F	23 Mar 58	CIC	Sat	Below Pred.	128
OB 6.08	24 Mar 58	HS	Sat	Normal	74
AM 6.38	24 Mar 58	PTD	Sat	Normal	85

Experiment Code

P—Pressure
T—Temperature
D—Density
W—Winds
M—Magnetic Field
AP—Auroral Particles
CIC—Chemical and Ion Composition
HS—Horizon Study
C—Cosmic Ray Intensity
CD—Charge Density in Ionosphere

across the haze horizon increases in contrast ratio much more rapidly as a function of altitude than brightness profiles witnessed at lower latitudes.

A special parachute recovery system was developed for these flights. This was the first firing of a recovery system in this vehicle in an Arctic region. The 85-pound nose section was recovered undamaged from an altitude of 74 miles.

Field Operations at Fort Churchill

A significant reason for the success of the Fort Churchill IGY rocket sounding program has been the unique construction and operation of the range facilities under Arctic conditions. Since many of the IGY rocket research organizations are laboratories within the Department of Defense, an Interservice Support Coordinating Group was established to coordinate logistic and range facilities provided by the three services. The group consists of representatives of the Army Signal Corps, the Air Force and the Navy, all under the supervision of a representative of Army Ordnance, which assumed responsibility for the establishment and operation of the range.

The launching complex itself consists of an Aerobee tower, movable in any direction to compensate for winds, a building to house the Nike-Cajun (or DAN) launcher, preparation buildings, telemetering trailers, a blockhouse, a generator building, a helium building, and connecting tunnels. Also included and installed were two radars, range safety plotting boards and a command transmitter, a frequency monitoring station, a timing system, meteorological and wind ballistic balloon launching facilities and sites, and a complete range communications system.

Numerous instrumentation sites are installed at various points throughout the military reservation at Fort Churchill. Included are a four-station DOVAP tracking system and ballistic cameras, two telemetering trailers, two ionosphere stations, and a network of sound-ranging geophones. (See Fig. 7)

With few exceptions, the rockets fired at Fort Churchill have been equipped with radio doppler (DOVAP) tracking beacons. These beacons serve as telemeter transmitters in addition to their primary function in the tracking system. Excellent trajectory data have been obtained on all rockets either to peak altitude or to break-up on reentry. This tracking system is in use at most of the major firing ranges in the United States and in other countries. The operational record at Fort Churchill indicates that the precision of the data is such that errors

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IGY Number Code Example: A M 2 21 F

Place 1. Directing Agency (A)
Place 2. Instrumenting Agency (M)
Place 3. Type of Vehicle (2)
Place 4. Directing Agency's Serial Number (21)
Place 5. Vehicle purchased with IGY funds through the National Science Foundation (F)

Symbols used in places 1, 2

A. Air Force Cambridge Research Center (AFCRC)
B. Ballistic Research Laboratories, Aberdeen (BRL)
I. State University of Iowa (SUI)
M. University of Michigan (MICH)
N. Naval Research Laboratory (NRL)
O. Army Ordnance
S. Army Signal Corps Engineering Laboratories (SEL)

Symbols used in place 3

1. Aerobee, Model RTV-A-1a (AJ10-25)
2. Aerobee, Model RTV-N-10c (AJ10-34)
3. Aerobee, Model RV-N-13c, called Navy Aerobee-Hi
4. Aerobee, Model AJ11-6, called Air Force Aerobee-Hi
5. Balloon-rocket combination, called Rockoon
6. Nike-Cajun rocket combination

Other

RPX. Rocket Project, Experimental

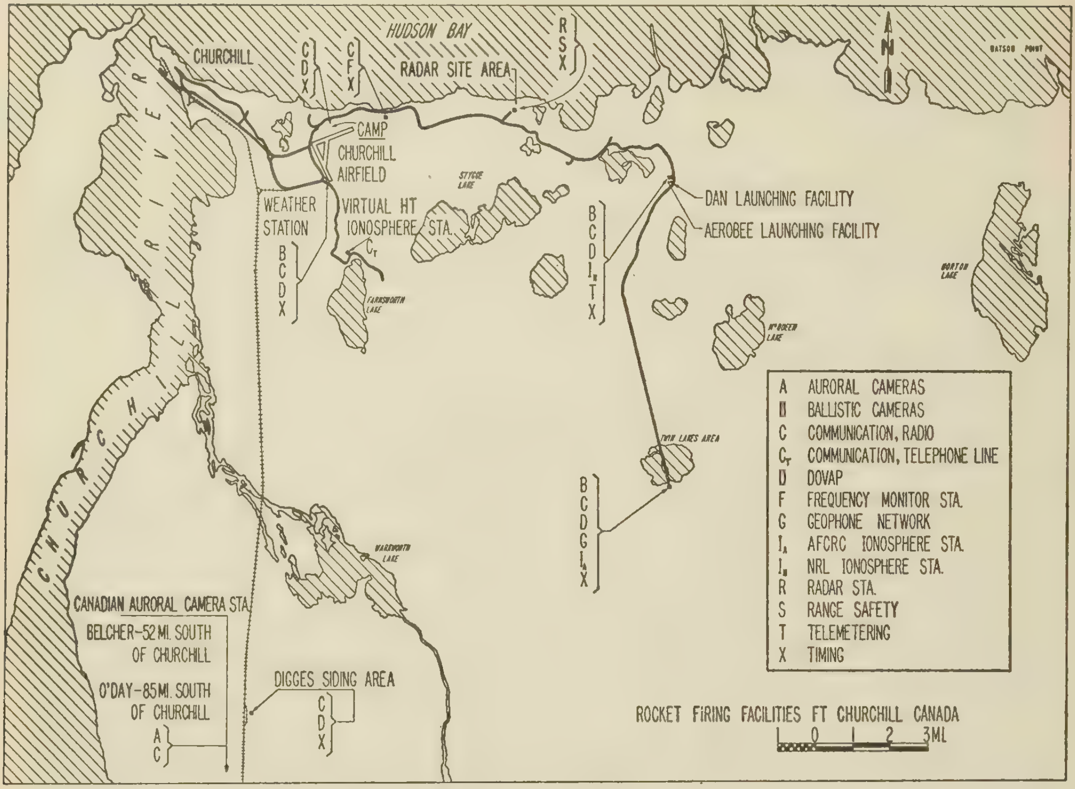

Fig. 7. *Instrumentation Site Locations at Fort Churchill.*

in altitude of less than 100 feet at rocket peak and in velocities of less than one foot per second have been commonplace. Such accuracies were required in many of the experiments.

An extremely important feature of the Fort Churchill IGY rocket program has been the very close cooperation of Canadian personnel. The Canadian IGY Committee and government agencies have provided most valuable assistance in the establishment and operation of this rocket range.

Life Sciences Experiments Using Earth Satellites

The possible uses of earth satellites for experiments in the life sciences were discussed by some 350 engineers and life scientists, representing both public and private institutions, at a symposium held in Washington, D. C., May 14–17, 1958. The symposium was planned and arranged by a 14-member steering committee appointed by Detlev W. Bronk, President of the National Academy of Sciences. The American Institute of Biological Sciences and the National Science Foundation joined the Academy in sponsorship of the meeting. Richard W. Porter, Chairman of the US-IGY Technical Panel for the Earth Satellite Program, served as symposium chairman.

The meeting had three basic objectives: (a) To stimulate thinking that will lead to a sound research program using earth satellites to achieve broad objectives in the life sciences, with an ultimate goal of manned space flight; (b) to exchange information

concerning the technical feasibility and scientific importance of various experiments on living organisms in the satellite environment; and (c) to discuss methods and techniques for conducting such experiments, including associated laboratory work.

Some discussion of current proposals for projects in the rocket, satellite, and space areas was arranged for life scientists participating in the symposium. There was additional discussion of engineering considerations in satellite research and of facilities that may become available to life scientists in the future.

Two sessions of the meeting were devoted to discussions of experiments in basic biology in the satellite environment. At another session, biophysical instrumentation required for research in the satellite environment was discussed. Subsequent sessions covered animal physiology in satellites, behavioral research involving both animals and man, and human physiology in space vehicles. The final session was devoted to discussion of funding of biological research using satellites. Opportunity was provided during the symposium for brief papers.

It is planned to make the proceedings of the symposium available to the public and the scientific community by publication at an early date. It is hoped that this publication will form the basis for a future US program of biological research using artificial satellites as a tool.

IGY Bibliography

Beginning with this issue, each Bulletin *will carry as broad a selection of bibliographic entries relating to IGY programs and findings as space permits. The references are selected largely from an IGY bibliography under preparation in the Science Division of the Library of Congress. This month's list includes a section covering the status as of May 1, 1958, of the* Annals of the International Geophysical Year.

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Status of IGY Annals

Eight volumes of the *Annals of the International Geophysical Year*, which constitute a central record of IGY activity, formal proceedings, and technical manuals used in the IGY program, have been scheduled by CSAGI (Special Committee for IGY).

Vol. I, History of IGY (in preparation).

Vol. II, Reports of IGY Conferences (in preparation).

Vol. III, IGY Instruction Manual—The Ionosphere, 381 pp., 1957.
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Part V, "Radioactive Fall-Out Data and Their Interpretation," pp. 307–362.
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Vol. VI, Instruction Manual for Rockets and Satellites (in press).

Vol. VII, List of IGY Stations (in press).

Vol. VIII, National Programs and Guide to World Data Centers (in press).

The *Annals* are published by the Pergamon Press, Ltd., 122 East 55th Street, New York 22, N. Y., and 4 & 5 Fitzroy Square, London, W.1.

IGY Rocket and Satellite Report Series

Data derived from results of experiments and observations conducted in connection with the IGY Rocket and Satellite Program are being issued in two series of reports published by the IGY World Data Center A subcenter for Rockets and Satellites. The two series are:

(a) IGY Satellite Report Series
(b) IGY Rocket Report Series

The subcenter has been established at the National Academy of Sciences by IGY World Data Center A, located in the United States (Data Center B is in the USSR and Data Center C is located in Western Europe and the Far East.)

Each report in the two series is priced at \$1.00, postage prepaid. Orders should be addressed to the Publications Office, National Academy of Sciences, Washington 25, D. C.

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To date, the following reports in the Satellite Series have been published:

No. 1—Processed Observational Data for USSR Satellites 1957 Alpha and 1957 Beta
No. 2—Status Reports on Optical Observations of Satellites 1958 Alpha and 1958 Beta
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